U.G. 6th Semester Examination 2022

PHYSICS (Honours)

Paper Code : DC - 14

(Statistical Mechanics)

Full Marks : 25 Time : Two Hours

The figures in the margin indicate full marks. Candidates are required to give their answers in their own words as far as practicable.

1. Answer any *five* questions : 2×5=10

(a) Write down Planck's energy distribution formula for black body radiation. Obtain Wien's formula from it.

(b) A system consists of three independent particles localised in space. Each particle has two states of energy 0 and $\in$. When their system is in thermal equilibrium with a heat bath at a temperature *T*, show that its partition function is $z = \left(1 + e^{-\in/kt}\right)^3$, where k = Boltzmann's constant.

(c) A particle is falling freely under the earth's gravitational field. Prove that its locus in the phase space is a parabola.

(d) State and deduce Stirling's formula.

(e) If P_i and P_j represent the probabilities of occupation of two energy states E_i and E_j $\left(E_j > E_i\right)$ by a classical system, show that the equilibrium temperature) of the system is $T = \dfrac{E_j - E_i}{k \ln\left(P_i / P_j\right)}$, where k = Boltzmann's constant.

(f) Sketch the F.D. distribution function $f\left(E_i\right)$ against energy E_i at temperatures $T = 0\,k$ and $T > 0\,k$.

(g) What do you mean by Bose-Einstein condensation ?

2. Answer any *three* questions : 5×3=15

(a) (i) Calculate the number of phase cells in the energy range from zero of E of a one-dimensional harmonic oscillator. 3

(ii) If two particles are distributed among two non-degenerate states, find the distributions according to MB and BE statistics. 2

(b) A system with energy levels given by $E_n = \left(n + \frac{1}{2}\right)\hbar w$ (n = 0, 1, 2, ...), is in thermal equilibrium with a heat reservoir at a temperature T. Find the partition function and hence the mean energy $\overline{E}$ in the limit $\hbar w \gg kT$. 3+2

(c) Obtain an expression for the molar specific heat of solid in terms of Einstein's characteristic temperature. How does the formula match the experimental results at low and high temperatures ? 4+1

(d) Five distinguishable particles are distributed in three non-degenerate levels with energies 0, E and $2E$. Determine the most probable distribution for a total energy $3E$. 5

(e) Consider two particles. Each particle can be in one of the three states with energies 0, E and $3E$. Find the number of micro-states of the system when the particles obey (i) BE statistics and (ii) FD statistics.

Also for the cases (i) and (ii), find the ratio of the probability of finding the particles in the same state to the probability of finding them in different states. 3+2